MODIS
Terra - Diffuse Attenuation Coefficient at 490 nm (K490)
Data Quality Summary

Investigation:	TERRA/MODIS
Data Product:	Product number - MOD 26, Parameter number - 23, Name - K_490 Diffuse Attenuation Coefficient (K490)
Data Set:	Terra
Data Set Version:	3.1.3 and 3.2.1
Principal Investigator:	D. K. Clark

Nature of the product

The attenuation of downwelling spectral irradiance, $E_d(\lambda, z)$ (in units of mW cm^{-2} nm^{-1}) at wavelength λ, is governed by the Beer-Lambert Law:

$$E_d(\lambda,z) = E_d(\lambda,0^-)e^{-K_{Ed}(\lambda,z)z}$$

where $K_{Ed}(\lambda,z)$ is the diffuse attenuation coefficient (in m^{-1}), averaged over the depth range from just below the sea surface (z = 0-) to depth z in meters. Although Austin and Petzold (1981) derived a K(490) algorithm for the NIMBUS-7 Coastal Zone Color Scanner for the upwelled radiance attenuation coefficient (K_{Lu}), both the SeaWiFS and MODIS K(490) algorithms replace K_{Lu} with the attenuation coefficient for downwelled irradiance, K_{Ed}. The algorithm to estimate MODIS $K_{Ed}(490)$ (see the MODIS ATDB 18, Bio-optical Algorithms - Case 1 Waters, available at: http://modarach.gsfc.nasa.gov/MODIS/ATDB/atdb_mod18.pdf) uses the MODIS total band ratio normalized water-leaving radiances at 488 and 547 nm substituted into the SeaWiFS postlaunch $K_{Ed}(490)$ algorithm (Mueller, 2000):

$$K_{Ed}(490) = 0.016 + 0.15645 \left[\frac{nL_W(488)}{nL_W(547)}\right]^{-1.5401}$$

where 0.016 is the pure water diffuse attenuation coefficient for $K_{Ed}(490)$ (based on Pope and

Fry, 1997 and modified by Mueller, 2000) and the coefficients a= 0.15645 and b= -1.5401 were determined by regression analysis (Mueller, 2000). The change in coefficients due to substitution of spectral bands (from SeaWiFS' 490 nm and 555 nm to MODIS' 488 nm and 547 nm) has not yet been addressed, but expected to be small. Mueller (2000) noted a small, but statistically significant, change in coefficients when using SeaWiFS bands 443 nm and 555 nm in the earlier CZCS (bands 443 nm and 550 nm) K(490) algorithm.

Another computational difference between this product and the SeaWiFS postlaunch K(490) algorithm, not yet evaluated, lies in the derivation of the solar normalized $nL_w(\lambda)$ values. Mueller (2000) used the Mueller and Austin (1995) definition which uses a measured $E_s(\lambda)$ to account for the combined effects of solar zenith angle, earth-sun distance, and transmittance through the atmosphere. The MODIS nL_w's used for this product are computed by the Gordon and Clark (1981) solar normalization model. The effects of the ocean's radiance distribution and its variability have not been accounted for in this approach.

Data Accuracies

Validation and an uncertainity assessment of the MODIS $K_{Ed}(490)$ algorithm has not been performed at this time. However, since the coefficients are identical to those used for the SeaWiFS $K_{Ed}(490)$, similar algorithm uncertainties are expected. Mueller (2000) reports that the SeaWiFS postlaunch algorithm does not perform well in water masses where $K_{Ed}(490) > 0.25$ m^{-1}. This lack of performance is due to the large uncertainties in both the measured $K_{Ed}(490)$ and the in-water measurements of nL_w's in extremely turbid water. The $K_{Ed}(490)$ product accuracy is directly dependent upon the uncertainties in the satellite retrievals of water-leaving radiances and the empirical results based on the in-water measurement analysis. This product is also subject to the MODIS sensors' east-west bias discussed in the pigment products 13-15 Data Quality Summary. Although the bias here is much smaller for the $nL_w(488)$, it is recommended that data processing version 3.2.1 and higher be used to minimize this problem with the retrievals.

Thresholds and Product Quality Level Flags

The product specific quality flag ranges from 0-3 and is based upon the uncertainties observed during the SeaWiFS $K_{Ed}(490)$ validation. Flags 0-2 are assigned only when the nL_w's are computed and the nL_w quality level indicates no known problems (nL_w flag =0). The $K_{Ed}(490)$ thresholds, ranges and associated uncertainties for the quality level flags are:

1. **If** nL_w's ($nL_w(488)$ or $nL_w(547)$) = -1 or the nL_w quality flag is not zero: **then** $K_{Ed}(490)$

product = -1; and QL flag = 3.

2. **If** $K_{Ed}(490) < 0.20$ m^{-1}: **then** the $K_{Ed}(490)$ QL flag = 0. Uncertainty = 18%

3. **If** 0.20 m$^{-1} \leq K_{Ed}(490) < 0.25$ m^{-1}: **then** the $K_{Ed}(490)$ QL flag = 1. Uncertainty = 20%

4. **If** 0.25 m$^{-1} \leq K_{Ed}(490) < 0.30$ m^{-1}: **then** the $K_{Ed}(490)$ QL flag = 2. Uncertainty >20%

5. **If** $K_{Ed}(490) \geq 0.30$ m-1: **then** the $K_{Ed}(490)$ QL flag = 3. Uncertainty = 50%

References

Austin, R.W. and T.J. Petzold, 1981. The determination of the diffuse attenuation coefficient of sea water using the Coastal Zone Color Scanner. In: *Oceanography from Space*, J.F.R. Gower, ed. Plenum Press, New York . p. 239-256

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Mueller, J.L., 2000. SeaWiFS algorithm for the diffuse attenuation coefficient, K(490), using water-leaving radiances at 490 and 555 nm. Chapter 3 of *SeaWiFS Postlaunch Calibration and Validation Analyses, Part 3*. NASA TM-2000-206892, Vol **11**, NASA GSFC, Greenbelt, MD. pp 24-27.

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